COUNTDOWN ACID RAIN

GOVERNMENT REVIEW OF THE 1994 PROGRESS REPORTS SUBMITTED BY ONTARIO'S FOUR MAJOR SOURCES OF SULPHUR DIOXIDE

(Final Countdown Program Report)

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EXECUTIVE SUMMARY

This is the government's review of the final (17th and 18th) semi-annual progress reports submitted by four Countdown companies, as required by Ontario's acid rain regulations. The Countdown Acid Rain program has been successfully completed and, to date, each of the four sources has met the legal limits for sulphur dioxide (SO_2) in the case of Inco, Falconbridge and Algoma at Wawa and in the case of Ontario Hydro, for SO_2 and acid gases (SO_2 plus nitric oxide [NO]). Reports were submitted to the Minister of Environment and Energy in July 1994 and January 1995 and covered the period from January 1 to December 31, 1994. Annual SO_2 emission caps have been established for the four SO_2 sources for 1994 onwards. These sources will continue to provide the Ministry with information on annual SO_2 and acid gas emissions to comply with their respective regulation.

From 1985 to 1994, SO_2 emissions in Ontario were reduced by about 56 % and in eastern Canada SO_2 emissions dropped by 66% from 1980 levels. Annual SO_2 emission caps of 885 kilotonnes (kt) for Ontario and 2.3 million tonnes for eastern Canada are in place. Ontario's most recent aquatic monitoring studies indicate that lakes in the Sudbury area are recovering but the recovery of lakes in south-central Ontario is slower than expected. Ontario's acid rain deposition monitoring network results show that areas receiving wet sulphate deposition greater than 30 kg/ha/yr have been significantly reduced in size but no substantial change has been noticed for areas receiving 20 kg/ha/yr wet sulphate deposition.

Specific details about each company's 1994 activities are provided below:

INCO LIMITED

In 1994, Inco estimated its SO_2 emissions to be 162 kilotonnes (kt). The company has successfully completed on schedule its SO_2 abatement program (SO_2AP) without outside financial assistance. The company spent over $612 million (Cdn $) in the past five years to reduce its smelter SO_2 emissions from 685 kt to 265 kt at an annual nickel production rate of 240 million pounds. The new flash smelting technology with bulk concentrate was commissioned in November, 1993 and since that time both flash furnaces have been operating at the design rate. Inco has yet to resolve some technical problems in the copper circuit dryer area. Inco is expecting improvements in local air quality for ground level SO_2 concentrations and for other contaminants (particularly metals) as a result of reductions in fugitive emissions by up to 70%. When these new smelting technologies are optimized, the company is expecting to save about $90 million annually from lower energy usage and productivity gains. Inco's current research and development work in the capture of SO_2 in the nickel matte processing fluid bed roaster off-gases if successful, could provide a further 30% reduction in annual SO_2 emission (below the 265 kt of SO_2/yr limit) from nickel smelting operations.

FALCONBRIDGE LIMITED

In 1994, the company estimated its SO_2 emissions to be 54.0 kt. The company reaffirmed its current operational capability to meet the 1994 annual SO_2 emission target of 100 kt at the smelter rated capacity. Falconbridge spent over $37 million from 1989 to 1993 in research and development and capital projects at the smelter and mill to meet its regulated SO_2 emission limit. The company completed rebuilding the No. 2 electric furnace (Single Furnace Project) in August 1994 at a cost of $13.3 million. Since November 1994 this new single electric furnace is handling all calcine produced by both roasters. The company's report indicates that these modifications have improved furnace operation. The company has achieved its goal of 17.2% metallization, resolved furnace bottom build up problems and decreased refractory wear and corrosion in the furnace. The company expects annual savings of about $3 million as a result of energy conservation and lower operating and maintenance costs from switching to a single furnace operation.

In mineral processing operations, Falconbridge has made further gains in pyrrhotite rejection and copper concentrate separation. Falconbridge is continuing with its research program in smelting and mineral processing areas to meet its voluntary annual SO_2 emissions target of 75 kt at the smelter rated capacity by 1998.

ALGOMA STEEL INC./ ALGOMA ORE DIVISION:

Algoma's SO_2 emissions from its sinter plant at Wawa for 1994 were estimated to be 35.5 kt, which is 72% below its 1994 limit of 125 kt. SO_2 emissions for 1995 are expected to be about 41.5 kt. The report indicates that the company plans to produce 1.32 million tonnes of sinter by using iron ore mined at Wawa, and by increasing the amounts of low sulphur iron oxides, mill scales, and possibly other iron/steel industry by-products as sinter plant feed in 1995 at this facility. The company is developing a business plan and contracts to ensure the viability of its sintering plant at Wawa.

ONTARIO HYDRO

Ontario Hydro's SO_2 and acid gas emissions for 1994 were estimated to be 106 kt and 135.5 kt, respectively. Both SO_2 and acid gas emissions in 1994 were slightly higher than in 1993 but much lower than the 1994 limit of 175 kt and 215 kt for SO_2 and acid gases, respectively. Fossil fuelled electricity generation was also lower (16.2 TWh) during this period compared to the early 1990s. In 1994, Hydro spent $137.0 million on measures contributing to acid gas control. About 47% of this expenditure was for premiums on low sulphur coal purchases. In 1994 the Lambton flue gas desulphurization (FGD) project was completed and two FGD scrubbers were put into service in the second half of 1994. These FGD scrubbers remove 90% of the SO_2 present in the flue gas. Also, Hydro completed combustion process modifications (CPMs) at Lambton unit #4 and anticipated NOx emission reductions of more than 30% from this unit. CPMs are planned for Lambton unit #3 in 1998, if needed. CPMs at Lambton, along with other NOx control measures, would enable Hydro to meet its voluntary annual target of 38 kt of nitric oxide (NO) per year by the year 2000. Hydro has installed flue gas monitors (FGMs) for measuring SO_2 and NO pollutants in the flue gas at all of its operating coal and oil fired boilers.

1.0 INTRODUCTION

Ontario's Countdown program is part of eastern Canada's Acid Rain Program (1985) which requires that sulphur dioxide emissions in eastern Canada (seven provinces east of Saskatchewan-Manitoba border) to be capped at 2.3 million tonnes starting in 1994; Ontario's share of this SO_2 cap is 885 kt. This was based on modelling long range transport of SO_2 emissions which indicated that a 50% reduction in Ontario's 1980 SO_2 emissions, if supported by similar reductions in eastern Canada and the United States, would be able to lower the wet sulphate deposition rate to 20 kilogram per hectare per year (kg/ha/yr), a level considered adequate to protect all but the most sensitive aquatic ecosystems in Ontario.

Four major corporate sources (Inco, Falconbridge, Algoma at Wawa, and Ontario Hydro) produced about 80% of Ontario's sulphur dioxide (SO_2) emissions in 1980. Each source was required by Ontario's **Countdown Acid Rain** regulations to report every six months on the progress made to reduce SO_2 emissions.

The Countdown program was formulated in 1985 and requires an annual SO_2 emission cap of 885 kt on all sources in the province, to be in place by 1994. Specific reductions for the major sources began in 1986 and culminated in a cap totalling 665 kt of SO_2 by 1994. In the case of Ontario Hydro, a limit was also placed on the combined emissions of SO_2 and nitric oxide (NO) and an interim cut of 35%, limiting SO_2 to 240 kt and acid gases (SO_2 + NO) to 280 kt, was also imposed for 1990-1993. The Countdown limits are in addition to point of impingement air quality standards imposed to ensure good ambient air quality. These annual legal limits for SO_2 are summarized in Table 1.

Table 1
Sulphur Dioxide Legal Limits
(kilotonnes per year)

	1985	1986	1990	1994
Inco nickel/copper smelter, Sudbury	728	685	685	265
Falconbridge nickel/copper smelter, Sudbury	154	154	154	100
Algoma iron ore sintering plant, Wawa	285	180	180	125
Ontario Hydro fossil fuelled power plants, province-wide	390	370	240	175
Legal Limits Sub-total:	1,557	1,389	1,259	665

Each of the four sources has met the legal limits to date and each has submitted detailed plans for implementing its reduction program, as required by the regulations. The sixth set of company progress reports, received in December 1988 (metallurgical companies) and

January 1989 (Ontario Hydro), set out the detailed methods and schedules for meeting the emission limits of the Countdown regulations. They were accepted by the government.

Implementation progress reports were required every six months. This document summarizes the contents of the 17th and 18th semi-annual progress reports and the government response; these officially end the implementation phase of the Countdown Acid Rain program. Future annual SO_2 emission compliance for these four regulated sources will be provided by an independent consultant audit of the company's reported annual SO_2 emissions. Previous semi-annual reports are available from the Public Affairs and Communications Branch, Ontario Ministry of Environment and Energy, 135 St. Clair Avenue West, Toronto, Ontario, M4V 1P5, (416) 323-4321 and Fax # (416) 323-4564.

2.0 PROGRESS REPORTS AND GOVERNMENT RESPONSE

The progress reports submitted by the four major sources were reviewed by the Countdown Technical Support Group (CTSG) drawn from the Ontario Ministries of Environment and Energy and Northern Development and Mines (for the metallurgical companies).

The implementation phase of the Countdown program is now complete. A summary of the individual reports and the Ontario government's response follows.

2.1 Inco Limited

Regulation 660/85 requires a reduction in annual SO_2 emissions from Inco's nickel/copper smelter complex in Sudbury so that emissions will not exceed 265 kt for any year beginning from 1994. The company was also required to examine the feasibility of going beyond the limit of 265 kt, specifically to a level of 175 kt at some future date. Several options were investigated by Inco and outlined in its sixth progress report (December 1988). Although the feasibility of further reducing SO_2 emissions has been identified, a commitment by the company is required to actively pursue the necessary research and development. The government previously accepted Inco's position that a specific interim reduction prior to 1994 was not feasible because of the nature of the major process changes being undertaken to meet the 1994 sulphur dioxide emission limit.

Company Report

The company's progress report covering the period January to December 1994 presents the following points:

- Inco has successfully completed its SO_2 Abatement Program outlined in the sixth semi-annual progress report (December 1988) to the Ministry on schedule and at a cost of $612 million.

- The report indicates that Inco has received individual certificates of approval (C of A) for recently submitted amendments regarding configuration and equipment changes to some smelter plant processes and the blanket Sulphur Dioxide Abatement Program (SO_2AP) certificate of approval has been revoked (December 31, 1994).

- Inco's new bulk concentrate flash smelting process is operating at design rate. Some technical problems in the copper recovery circuit remain to be resolved but the company engineers are confident that these will be resolved in 1995.

- In May 1994 the roof of one of the flash furnaces collapsed and the furnace was shut down for 3 weeks. Problems were identified with the original tapered roof design and were corrected by using tongue and groove design for side wall bricks. The repaired furnace has been operating satisfactorily since June 1994.

- Inco estimated its 1994 smelter SO_2 emissions to be 162 kt.

- In September 1994 Inco tested all three smelter stacks (namely, 381 m Superstack, acid plant tail gas exhaust stack and old copper circuit stack currently used for collecting and discharging fugitive SO_2 emissions from flash smelting and MK reactor operating areas) for SO_2, particulates and selected trace metal discharged to atmosphere. The final report will be submitted to the Ministry in 1995 for review and assessment of compliance with current MOEE standards.

- The report indicates that Inco is using natural gas burners in an attempt to maintain the stack gas temperature above dew point (at about 120°C). Studies are also going on to assess the impact of lower gas temperature on stack corrosion and SO_2 dispersion.

- The company has completed revisions to the sulphur mass balance method based on its new bulk smelting process.

- The report indicates that Inco is also expecting air quality improvements in the Sudbury airshed from its recently completed SO_2AP with substantial reductions in SO_2 emissions. The extent of the improvements is somewhat uncertain.

- In response to the Ministry's request Inco has undertaken a fugitive emission study to link fugitive SO_2 ground level concentrations, activities in the smelter and weather conditions. A final report will be submitted to MOEE's Sudbury office.

Research & Development Activities

- Inco indicated to the Ministry that the pilot work on continuous converting with SO_2 emissions capture at the Port Colborne plant did not yield satisfactory results due to high metal losses and had been discontinued.

- Planned research at Copper Cliff (Sudbury) concentrates on the capture of SO_2 from matte processing fluid bed roaster off gases in the acid plant. Some tests are being planned in this area in 1996 and the use of Port Colborne equipment is being evaluated.

- Research will also be conducted on corrosion problems related to the copper circuit dryer and the removal of trace metals.

Government Review

The government review has concluded that Inco continues to meet the requirements of Regulation 660/85.

The CTSG review team is pleased to note that the company has successfully completed its Sulphur Dioxide Abatement Program (SO_2AP) on time and without any outside financial assistance. The CTSG is also pleased with Inco's intent to achieve further reduction in SO_2 emissions from still uncontrolled smelting processes at this location.

SO_2 Emissions

- Inco's estimated SO_2 emissions of 162 kt from its smelting operations in 1994 were 55% less than 1993 emissions and 39% below the legal limit of 265 kt for 1994. Two plant shutdowns, one in January-February and the other in July contributed to lower than usual smelter SO_2 emissions in 1994. Inco has submitted the 1994 SO_2 emissions audit report to the Ministry.

- In 1995, the company had a two week summer shutdown and the smelter operated at normal production rate. In the first half of 1995, SO_2 emissions were estimated to be 103 kt.

SO_2 Fixation:

- The newly built 3000 tonnes/day double contact sulphuric acid plant and associated gas cleaning system has operated satisfactorily and no significant technical problems have been reported by Inco. Also, the existing 280 tonnes/day liquid SO_2 plant underwent some minor piping changes during the summer shutdown; changes to the drying section in the gas cleaning tower were not needed due to the high strength SO_2 gas. The liquid SO_2 plant is operating well and is producing an acceptable quality of product.

- Inco's new acid plant technology is an integral part of the bulk smelting technology such that if either of the systems face operating problems, the entire system would have to be shut down. This will provide protection to the environment from elevated SO_2 emissions due to possible upsets from the nickel and copper concentrate smelting operations.

- Inco is currently achieving ≥ 90% sulphur fixation based on the sulphur present in the ore at this smelter with their improved mineral processing and new bulk concentrate flash smelting technologies.

General Comments

- The Ministry concurs that the company has received all Certificates of Approvals for the SO_2AP.

- Statistics show that complaints regarding SO_2 exceedences from the smelter were considerably lower in 1994 than 1993. However, Inco's claim regarding the improvement in local air quality from the SO_2AP requires to be assessed for longer periods.

- With the new milling and smelting technologies in place, a reduction of up to 70% in fugitive emissions (both SO_2 and particulates) from 1980 levels is expected. Studies in this area to confirm these expectations are in progress.

- The responsibility to prepare future SO_2AP progress reports was transferred to Inco's Ontario Division in 1994. The company has agreed to provide an annual progress report to the Ministry on a voluntary basis. Details regarding timing and contents are currently being discussed between the Ministry's regional staff and the company.

2.2 Falconbridge Limited

Regulation 661/85 requires Falconbridge to reduce its annual SO_2 emissions from its Sudbury nickel-copper smelter complex to less than 100 kt from 1994 onwards. The regulation also requires Falconbridge to evaluate the technical feasibility of further reducing SO_2 emissions to a specific level below 100 kt.

Company Report

The 17th and 18th semi-annual progress reports, covering the period from January to December 1994, present the following points:

- Falconbridge has satisfactorily completed the SO_2 abatement program outlined in its 6th Semi-Annual Progress report (December 1988) and has complied with its 1994 SO_2 emissions limit of 100 kt. In 1994, the company estimated its sulphur dioxide emissions to be 54 kt. Falconbridge has submitted its 1994 SO_2 emissions audit report to the Ministry.

- This SO_2 emission reduction achievement was the result of technical developments and operational improvements by the company such as improved pyrrhotite rejection, increased degree of roasting to remove more sulphur from nickel concentrate and fixation of SO_2 produced in sulphuric acid plant, enhanced slag cleaning operation to lower metal losses, separate copper concentrate production to improve furnace operation, and increased smelting of recycled materials free of sulphur along with increased pyrrhotite rejection at its Strathcona Mill ore treatment plant. With these modifications the company achieved the operational capability of meeting its 100 kt SO_2 emissions annual limit 3 years earlier than required by Regulation 661/85.

- Falconbridge has spent over $37 million between 1989-1993 to make these process changes, will continue to invest capital in the Strathcona Mill and smelter, and will conduct research and development in promising areas. This investment will enable the company to meet its voluntary SO_2 emission target of 75 kt at the smelter rated capacity by 1998.

- In 1994, $18.7 million were spent on the Mill and Smelter capital projects and $1.0 million on research related to SO_2 abatement projects.

- **Smelter Modifications - Single Furnace Project:**

  - The rebuilding of a 'Single Furnace' (old Electric Furnace #2) was completed in August 1994 and its commissioning took place in October 1994. Since November 1994 the furnace has been processing calcine (furnace feed) from both roasters and producing nickel copper matte of acceptable quality.

  - The rationale for rebuilding #2 Furnace was: (i) to reduce metal losses to slag, (ii) to lower furnace bottom build up from smelting calcine with lower sulphur content, (iii) to decrease refractory deterioration from higher temperature furnace operation and (iv) to lower power usage and operating and maintenance costs.

  - Since switching to single furnace operation Falconbridge has achieved on average 17.2% metallization in matte, the bottom build up problems appear to have been resolved and the furnace is operating with less refractory wear. However, some refractory problems in the tap hole area still remain to be resolved. The company engineers are hoping to overcome these difficulties shortly.

- The company spent $13.3 million in 1993-94 to make the necessary changes to No. 2 electric smelting furnace. These modifications are expected to provide a competitive edge in nickel production costs to Falconbridge.

- **Acid Plant**

  - The company operates a single contact acid plant (1088 tonnes/day) to convert SO_2 present in roaster off-gases to sulphuric acid, a marketable by-product. The plant efficiency is about 96%.

  - The report indicates that two mist precipitators were upgraded and commissioned in 1994 at a cost of $1.4 million. These changes would help reduce corrosion and fouling of downstream equipment and maintain acceptable acid quality.

- **Strathcona Mill Modifications**

  In 1994, four projects were actively worked on:

  (i) DCS (distributed control system) to improve process control and management information systems;

  (ii) installation of large floatation cells (37 cu.m) to provide better control of feed to the pyrrhotite (Po) rejection circuit. When completed all rougher and scavenger flotation will be carried out in these cells;

  (iii) upgrading of pyrrhotite rejection circuit: When completed in 1996 these changes will provide more stages of cleaning and higher Po rejection. Earlier changes made in the re-grinding circuit and treatment of secondary rougher concentrate with magnetic separators have improved Po rejection from 70% to over 83%.

  (iv) increasing of capacity of the copper scavenger circuit: When completed these 12 new 8.5 cu.m (300 ft^3). Outokumpu cells will increase copper concentrate separating capacity of this plant from 63% to 70%.

- The company spent over $4.5 million in 1994 on these projects.

- **Research & Development Activities**

  1. Smelter: the company's R & D activities are now concentrating on high capacity operation of the single furnace and to increase metallization from 17% to 23%. To

reach this goal the company is also sponsoring research studies at McMaster University on furnace mass and heat transfer.

2. Strathcona Mill: the research on improved Po rejection with the addition of new reagents is continuing at the company and at McGill University and Western Ontario University laboratories. Pilot plant studies to develop processes for Po rejection and for improved copper nickel separation are also continuing at good pace. The company is also evaluating modifications to simplify Strathcona Mill operations to handle larger throughput and maintain higher Po rejection efficiency to the re-grinding circuit.

Government Review

The Countdown Technical Support Group (CTSG) concluded that the company's 17th and 18th semi-annual progress reports met the requirements of Ontario Regulation 661/85. The CTSG is satisfied with the technical progress Falconbridge has made in meeting its SO_2 emissions limit of 100 kt at design smelter production capacity three years ahead of schedule. Promising areas for further reductions have been identified by the company. The CTSG is further encouraged to note that continuing investments in R & D and recent successes in research and development projects will likely enable Falconbridge to achieve its voluntary SO_2 emissions target of 75 kt/yr at the smelter design capacity by 1998.

Additional CTSG comments are as follows:

- The recently completed single furnace project is expected to provide annual savings of about $3.0 million to the company from energy conservation and lower operating and maintenance costs.

- The combined sulphur fixation at the smelter is in the range of 80-82% and covers slag, matte and acid production. The company's total sulphur (S) fixation based on S in ore mined is $\geq$ 90%.

- The CTSG is satisfied with Falconbridge's explanation that SO_2 emissions of about 40 kt/yr associated with copper concentrate separated at Strathcona Mill (up to 180 tonnes/day) are contained appropriately at other company locations.

- The CTSG concurs with the company's statement that reaching lower annual SO_2 emissions target of 75 kt/year by 1998 appears to be on track in spite of adverse economic impacts from variable international nickel markets.

- The company's request for a more flexible Certificate of Approval (C of A) amendment process for making future smelter process changes to reach its voluntary 75 kt SO_2 emissions target was reviewed; the company was informed at an October 1994 meeting that this would not be possible due to the requirements of the Environmental Bill of

Rights (EBR). Ministry staff will cooperate with the company to speed up the approvals process if they are consulted in a timely fashion.

- All other issues of concerns to the Ministry arising from company previous progress reports were resolved at an October 1994 meeting with the company representatives.

- The company agreed to provide an annual progress report to the Ministry, on a voluntary basis, on its activities related to SO_2 abatement.

2.3 Algoma Steel Inc.

Algoma Steel Inc. (Ore Div.) operates an iron ore sinter plant at Wawa, about 270 km northwest of Sault Ste. Marie. Regulation 663/85 limits SO_2 emissions from the sinter plant to 180 kt per year for 1986 to 1993, further dropping to no more than 125 kt per year, effective in 1994.

In August of 1986, the sinter production capacity at Wawa was permanently down-sized by about 50 per cent. The lower production rate when combined with reduced sulphur levels in the feed, has resulted in substantially reduced SO_2 emissions.

Company Report

The company's 17th and 18th semi-annual progress reports covering the period from January to December 1994 confirm that the company will meet its 1994 and future SO_2 emission limit of 125 kt by reduction in sinter capacity. In addition, continued and possibly increased use of low sulphur iron oxides at Wawa plant could further reduce current levels of SO_2 discharged from the sinter plant stacks.

The 17th and 18th semi-annual progress reports also provide the following information:

- The 18th semi-annual progress report states that Algoma has reduced its SO_2 emissions at the Wawa plant considerably below the 1994 requirements. In 1994, the Algoma Ore Division reported its estimated SO_2 emissions to be 35.5 kt. Algoma has submitted its 1994 SO_2 emissions audit report to the Ministry.

- The sinter production was 1.07 million tonnes in 1994.

- The company forecasts 1995 SO_2 emissions to be about 41.4 kt at a sinter production rate of 1.32 million tonnes. The average sulphur content of the sinter plant feed is expected to be 1.4%.

Government Review

- The CTSG has concluded that the company continues to meet the requirements of Regulation 663/85.

- Algoma's 1994 SO_2 emissions were 72% lower than the company's current limit of 125 kt.

- The company plan indicates that use of low sulphur iron oxides and mill scale in sinter plant feed will be continued and should help to maintain current and projected annual SO_2 emissions to about 60 kt or less, which is well below the 1994 limit of 125 kt.

- An Algoma Ore Division (A.O.D.) management committee is developing a business plan and contracts to assess continued viability of the Wawa sintering plant operation. Algoma's steel production has increased in recent years and the iron ore is still supplied by a Wawa mine to the sintering plant.

- Algoma expects to increase steel production in future and no sinter tolling was done at the Wawa plant in 1995.

2.4 Ontario Hydro

Regulation 355, R.R.O. 1990 (formerly O.Reg. 281/87) requires Ontario Hydro to meet interim annual emission limits for the 1990-93 period and imposes a tighter limit for 1994 and beyond. Separate limits are set for SO_2 alone and for the sum of SO_2 plus NO (nitric oxide), as shown in Table 2.

Table 2
Ontario Hydro's Sulphur Dioxide and
Acid Gas Emissions Limits

Period	Regulated Limits	
	SO_2	SO_2 + NO
	(kilotonnes per year)	
1986 to 1989	370	430
1990 to 1993	240	280
1994 and future	175	215

Company Report

The corporation reported that in 1994 acid gas emissions were estimated at 106 kt of SO_2 and 135.5 kt of acid gases (SO_2 plus NO), respectively. The reported SO_2 and acid gas emissions were slightly higher by 11% and 2.6% respectively than those in 1993. Fossil-fuelled electricity generation in 1994 was 16.2 TWh (tera watt hours), about 10% less than that in 1993.

Ontario Hydro has submitted the 1994 SO_2 and acid gas emissions audit report to the Ministry.

Acid Gas Control Costs:

The corporation reports that expenditures of $137.0 million were incurred for the period from January to December 1994 on measures contributing to the reduction of acid gas emissions, as follows:

- $67.3 million was spent for flue gas desulphurization (two FGD scrubbers) for the Lambton Thermal Generating Station (TGS).
- $1.5 million expenditure was incurred for flue gas conditioning at Nanticoke and Lambton stations. This measure allows Hydro to burn lower sulphur coal at these locations without exceeding stack opacity limits and boiler derating.
- $2.5 million was spent for combustion process modifications (CPMs) at Lambton Unit #4.
- $64.3 million was spent on low sulphur coal premiums, which was partly for acid gas control. This is approximately 38 % lower than the premiums paid in 1993 and accounted for 47% of the total expenditure reported by Hydro for acid gas control in this report.
- $920,000 was allocated for compliance with the emissions verification and reporting order issued by the Ministry in June 1990.
- $480,000 was allocated for research and development.

Acid Gas Control Programs:

SO_2 Controls

- Two flue gas desulphurization scrubbers were put into service at Lambton units 3 and 4 in July and October 1994, respectively. Both scrubbers are operating at about 90% SO_2 removal efficiency as per design. The project was completed on time and within the budget of $537.5 million.

- The 17th and 18th semi-annual progress reports also indicate that the flue gas conditioning (FGC) equipment with sulphur trioxide (SO_3) and ammonia (NH_3) conditioning agents has been decommissioned at Lambton units 3 and 4 since these two units burn high sulphur (2.5%) coal and is working well for all units at Nanticoke. Lakeview TGS units 5 and 6 only use SO_3 (sulphur trioxide) for conditioning flue gas. FGC systems are used to avoid opacity problems and boiler derating when using lower sulphur coals for fuel.

NOx Controls

- Hydro is assessing the technical feasibility of implementing NOx emission controls on existing fossil fuel stations. Combustion process modifications (CPMs) for unit #4 at Lambton have been put into service since the fall of 1994 and are working well. Hydro plans to install CPMs at Lambton unit #3 by 1998, if needed.

- Hydro is expecting to complete their selective catalytic reduction (SCR) program jointly with Southern Company Services on North American coals by the end of 1995.

- Hydro is also planning to conduct a pilot urea injection study including an hybrid of Selective Non Catalytic Reduction (SNCR) and SCR systems in 1995-96 and is currently evaluating locations and partners for this study(ies).

Emissions Monitoring:

- The report also indicates that Hydro has installed flue gas monitoring devices (FGMs) on most fossil-fuel boilers in order to meet the Ministry's acid gas (SO_2 and NO) emissions verification and reporting order requirements. All FGM systems at Nanticoke, Lambton, Thunder Bay and Atikokan have completed Relative Accuracy Test Audit (RATA) and calibration drift tests. Lakeview and Lennox stations are exempted from FGM verification tests until their annual capacity factor is above 20% on a unit basis and will be using current sulphur mass balance and nitric oxide (NO) emission factors for estimating and reporting SO_2 and NO emissions from these thermal generating stations.

- Hydro completed a 6 month comparison study at the Nanticoke TGS Unit #2 to demonstrate the accuracy of SO_2 and NO emission measurements of the FGM system and in-stack continuous emission rate monitoring (CERM) system in the mid 1994 and submitted a document on statistical analysis of the study results to the Ministry.

- Hydro also updated NO vs. Load curves for most of their fossil fuel operating boilers in 1994 using information generated by FGM monitors and a report detailing the procedure and updated NOx vs. Load curves was submitted to the Ministry. The information will be used to estimate 1995 NO emissions from Hydro stations.

Emissions Trading

- Hydro is taking initiative in NOx emission reduction trading and has established a multi-industry working group to develop proposals and start discussions with the government in this area.

Government Review

Some points noted by the reviewers are listed below:

- The CTSG concluded that Ontario Hydro's 17th and 18th semi-annual progress report were submitted on time and had met the requirements of Regulation 355 R.R.O. 1990 (formerly O. Reg.281/87).

- The CTSG further noted that still a large portion of Hydro's acid gas control expenditures reported in 1994 was for the premium on low sulphur coal purchases. Since the two Lambton FGD scrubbers are now in service, Hydro expects to lower premiums paid for low sulphur coal in future.

- The CTSG is pleased to note that Lambton FGD project was completed on time and within budget. The Ministry now awaits completion of the QA/QC manual for Lambton's two continuous emission rate monitoring (CERM) systems so that appropriate and accurate SO_2 and acid gas emissions can be estimated and reported from these units.

- The combustion process modifications (low NOx burners) installed at Lambton's unit #4 are providing between 29% to 49% reduction in NOx emissions from this unit. Hydro is in the process of optimizing boiler operating conditions to achieve maximum NOx reductions.

- Hydro's FGMs installed at the Nanticoke, Lambton, Thunder Bay and Atikokan units have met RATA requirements of $\leq$ 20% relative accuracy (RA) and calibration drift (CD) tests as per the agreement between MOEE and Hydro.

- In 1994 Hydro developed new NOx versus Load curves for all operating units using FGM systems as required under the emissions verification and reporting Order. The final report submitted by Hydro on this topic to the Ministry is under review.

3.0 CONCLUSIONS

- The Countdown Acid Rain program has been very successful. This program has reduced Ontario's actual SO_2 emissions by 56% from 1980 levels.
- All four regulated corporate sources have successfully implemented their SO_2 abatement programs and met their 1994 emission(s) targets. Their combined 1994 SO_2 emissions were 356 kt, 46% below the 1994 limit of 665 kt.
- Ontario's 1994 SO_2 emissions were 618 kt; 30% below the provincial emission cap of 885 kt.
- The feasibility of further SO_2 emission reductions by the metallurgical companies (Inco, Falconbridge) exists and should be actively pursued.
- Recent aquatic effects monitoring data indicate that lakes in the Sudbury area are recovering but recovery of lakes in south-central Ontario is slower than expected.
- Deposition monitoring results show that acid rain sensitive areas receiving annual wet sulphate deposition of $\geq$ 30 kg/ha/yr have been reduced but there is no substantial change in areas receiving 20 kg/ha/yr wet sulphate deposition.
- These new findings suggest that although Ontario, along with future U.S. SO_2 emission reductions, could achieve the wet sulphate deposition target of 20 kg/ha/yr, full recovery of acid rain impacted lakes is still somewhat uncertain.

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